Tanna pallida, sp. n.

♂. Body and legs very pale tawny brown; pronotum with a central pale ochraceous fascia, on each side of which is a short longitudinal black discal spot, the sublateral fissure black and the anterior fissure brown (these dark markings apparently absent in female); mesonotum with two obsolete obconical spots, which are only defined by their somewhat darker margins, a small black spot on each side of cruciform elevation; abdomen finely palely pilose, somewhat in tufts on lateral margins; tegmina and wings hyaline, the venation and costal membrane of the first pale ochraceous; opercula small, subtriangular, just passing the base of abdomen; rostrum reaching the posterior coxæ; a single tubercle on each side of second abdominal segment; face moderately globose and strongly centrally striate.

Long., excl. tegm., ♂ 19, ♀ 17 mm.; exp. tegm., ♂ 55, ♀ 62 mm.

Hab. North Borneo; Sulu Islands, Jolo.

XXI.—*Flying-fish Flight, and an Unfixed Law of Nature.* By Lt.-Col. C. D. Durnford.

The controversy amongst naturalists as to whether flying-fish do or do not flap their wings in flight has become so one-sided as almost to represent extinction—as a controversy.

It is desirable, if possible, to revive it a little, by carrying the argument into new ground: first, because the one side which is at present believed in would appear to be the wrong one; and, secondly, because it seems to have escaped the notice of the other that this is capable of proof.

The arguments, if they may be so called, hitherto in use are simple assertion and denial, and may be summed up into:—

> "Flying-fish do fly, moving their wings with extreme rapidity. I have carefully and frequently watched them, and there can be no doubt whatever about it."

And the converse:—

> "Flying-fish do not flap their wings, but use them as aeroplanes, like swallows when in skimming or sailing flight. I have carefully and frequently watched them, and there can be no doubt whatever about it."

Somewhat similar remarks will be heard in any ordinary group of ship's passengers watching the fish. Some will insist that they see the wings flapping, and some will aver that they are quite still.

But among scientists wing-flapping is undoubtedly very much the under-dog, and the carefully written paper by Captain Barrett-Hamilton (Ann. & Mag. Nat. Hist. vol. xi. p. 389, 1903), also a convinced aeroplanist, perhaps expresses current opinion as well as may be; and even Professor Whitman ('American Naturalist,' vol. xiv. p. 641, 1880), who insists that he has seen "distinctly the individual flaps of the large pectorals," adds that this flapping "may be continued for the whole or part of the flight, but it is generally discontinued after the first few rods, and the course continued by a pure skimming or sailing movement"—thus showing that he, too, believes in the possibility of the aeroplane flight.

Proof that such flight by any known species of flying-fish is a mechanical impossibility is the new ground which I propose to take up.

In order to make clear what the aeroplane theory is, I quote from the 'Encyclopædia Britannica' (art. "Flying-fish") the "chief results of the inquiries" ('Die Bewegungen der Fliegenden Fische durch die Luft,' Leip. 1878) of one of its chief exponents, Professor K. Möbius. These results, which seem also to have formed the groundwork of many subsequent articles, are—with certain omissions on my part for brevity's sake—summed up as follows:—

"They are more frequently observed in rough weather, and in a disturbed sea than during calms; they dart out of the water . . . . and they rise without regard to the direction of the wind or waves. The fins are kept quietly distended without any motion, except an occasional vibration caused by the air, whenever the surface of the wing is parallel with the current of the wind. Their flight is rapid, but gradually decreasing in velocity, greatly exceeding that of a ship going ten miles an hour, and a distance of 500 feet. Generally it is longer when the fishes fly against, than with, or at an angle to, the wind. Any vertical or horizontal deviation from the straight course, when flying with or against the wind, is not caused at the will of the fish, but by currents of air. . . . . in a rough sea, when flying against the course of the waves; they then frequently overtop each wave, being carried over it by the pressure of the disturbed air. They . . . . fall on board vessels. This never happens from the lee side, but during a breeze only, and from the weather side. During the night they frequently fly against the weather-board, where they are caught by the current of air and carried upwards to the height of 20 feet above the surface of the water, whilst under ordinary circumstances they keep close to it."

The above is fairly representative of the aeroplane theory. There are, however, several variants to it, the most notable being the addition by later writers of the use of the tail, both as a propeller in air, and also as an explanation of the loud buzzing sound always heard when the fish fly near or over a boat, and which is really made—it seems odd to have to write it—by the rapid whirring of the wings.

Of this whirring or flapping motion Professor Whitman writes, "It is so rapid that it is not easily recognised at any great distance until experience has sharpened the eye." Therein lies, I think, the cause of the birth of the aeroplane theory, though I must add that experience need not necessarily sharpen even good natural sight into being able to see the wing-movement. Knack or chance may come in in such matters. Some time ago, for instance, I was astonished, whilst testing the shooting of a shot-and-ball gun at the butts, to find that in certain lights I could plainly see the ball during its whole flight, whilst the attendant, whose daily business it was to test rifles and guns, and whose sight was far superior to mine, tried over and over again but could not pick it up. So have I seen many watch the whirring wings and declare them to be still.

It is commonly accepted that in matters of observation an affirmative evidence is superior to a negative one. In the special case under consideration, the value of the affirmative true flight evidence is very greatly increased by the fact that the aeroplane contradiction thereof must be in proof of a unique act in nature without a known parallel. Flying lizards and flying squirrels are perhaps the nearest, but in both cases the aeroplane is, I believe, greater by far compared with the weight borne, and—of more importance—the course is certainly far less and falling, not horizontal, or rising, as is that of the flying-fish.

Surely, therefore, it is not too much to ask from the aeroplanists either a reference to some mechanical parallel, or else absolutely overwhelming evidence in favour of the marvellous —a fair expression if no parallel be produced. We do not receive the evidence, for, as before noted, it consists of a series of witnesses very fairly divided as to whether they can or cannot see the wing-movement, although scientific writers on the subject nearly all follow the latter. We do receive reference to certain parallels, and I shall endeavour to examine these with such lights as I can find. The parallels are, first, the "sailing" or skimming flight of birds (swallows being usually mentioned), and, secondly, parachutes.

For purposes of comparison in this examination, we will take a typical flying-fish. I have the wings of one, which flew on board a steamer on which I was travelling, before me as I write. Its weight was just over a pound, and it had a wing-area of 62 square inches, very liberally computed.

Let us consider the bird-flight first. Concerning this we have certain recognized facts to guide us, for which I refer readers to Professor E. J. Marey's work on 'Animal Mechanism' (International Science Series, vol. xi. pp. 221–225, 1874).

We are specially concerned in his acceptance therein of the division of birds into two main classes, viz., those largely given to "sailing" or still-wing flight (which class is found to be endowed with a large wing-surface), and those which confine themselves more to the "rowing" or wing-flapping flight (which, as a class, has short and narrow wings).

"If," says Professor Marey (*loc. cit.* p. 221), "we compare together two rowing, or two sailing birds . . .," arranging as far as possible "to have no difference between them except that of size, we shall find a tolerably constant ratio between the weights of these birds and the surface of their wings." Tables are added of this ratio in various birds, as found by dividing the square root of their wing-surface in square centimetres by the cube root of their weight in grammes.

I will from these tables give this ratio for three of the sailing-birds and for three of the rowing-birds, including the two lowest ratios of the latter. I will add on my own account the ratio for the flying-fish, which is quite properly comparable with birds in this respect. (See table, p. 162.)

Note the place of the flying-fish. It is quite in its proper position as a very low order of wing-flapper, requiring great wing-speed to sustain it in air. Note also the representative of the swallow tribe, weighing considerably under an ounce, in its proper place in the sailing class. The *Hirundo rustica*, or swallow proper, would doubtless hold a higher place still—our principal parallel, whose featherweight ought to have protected us from the comparison.

The figures should be convincing; I will not, therefore, comment more upon this, but proceed to another test, viz. to find what size of wing a one-pound (453 grammes) fish would require to raise it into the sailing class. No birds are dealt with by Marey of exactly one pound weight; I will therefore take the next above and the next below that weight.

Name.	Weight $=p$ in grammes.	Surface of wings $=2a$ in sq. cm.	Ratio $=\frac{\sqrt{2a}}{\sqrt[3]{p}}$.
Falco palustris . .	208·76	1188	5·810
Falco sublatio (?) *	509·62	1684	5·138
Hirundo urbica (House-martin).	18·00	120	4·180
Columba vinacea .	112·00	292	3·545
Saxicola œnanthe .	56·05	125	2·922
Perdix cinerea . .	280·00	320	2·734
Exocœtus (Flying-fish)	453·59	400	2·603

* [Qu. *subbuteo*?—Eds.]

The *Falco sublatio* shown has a weight of 509 grammes and a wing-area of 1684 sq. cm., with ratio of 5·138, and the *Corvus cornix* has a weight of 374 grammes and a wing-area of 1156 sq. cm., giving a ratio of 4·717.

Our one-pound flying-fish, to enable it to sail, would thus require a wing-area between three and four times greater than the 400 sq. cm. which it possesses. And, mark this, even then it would only sail as birds sail, in favourable winds and circumstances, falling and rising and using the "rowing" flight frequently, as may be necessary, not as our fishes go, "without regard to the direction of the wind," horizontally, and close to the water, and, according to aeroplanists, with ever still wings! Further, "concave bird-like surfaces afford from three to seven times as much support as planes" (Encyc. Brit., art. Aeronautics—*re* flight). It has been pointed out to me that it is extremely improbable that a flying-fish's wings can assume this concave shape. If this be so, "from nine to twenty-eight" may be substituted for the "between three and four" times above.

Need I go on? I am afraid so—superstitions, especially learned ones, die hard. So to the second parallel offered us, the parachute. The term implies the act of falling through the air, and not the horizontal or the rising motion with which we are dealing. Still, the word has been used in explanation of the fish's supposed deeds, and I will try to deal with it and at the same time keep clear of the pitfalls which will surround the effort.

Professor Möbius puts the speed of the flying-fish as "greatly exceeding that of a ship going 10 miles an hour." George Bennett ('Wanderings in New South Wales,' vol. i. p. 31, 1834), much quoted, puts its extreme time in air at 30 seconds "by the watch," and its distance at 200 yards; this works out at rather over 13½ miles an hour, extreme rate. It will, perhaps, give a sufficiently large margin to call the fish's average speed 15 miles an hour.

Now if wind and a body, either or both in motion, meet at a rate of 15 miles an hour directly against each other, the body having 1 square foot of surface, the pressure exerted thereon will be 1·107 lbs. That, I think, implies that if a flying-fish weighing a little over a pound and having a wing-surface of 144 square inches (an impossibly large one, of course, for such a fish) were falling through still air, it would descend at the rate of about 15 miles an hour; or, on the other hand, if it were in a wind blowing 15 miles an hour straight upward from the sea (an impossibly favouring wind, of course) it would just be supported. I will leave it entirely to my readers to imagine the effect in the second case upon our fish of reducing its wing-area from the suppositious 144 sq. inches to its actual 62 sq. inches.

If the reader's imagination is not sufficient to drop the fish into the sea at once by the reduction, then let him add the effect of removing as much support as would be taken away by changing the impossible upward-blowing wind into the ordinary horizontal one at the same 15 miles an hour speed, meeting the wings at an acute angle. There are pitfalls here, so I will avoid angles and calculations, and merely point out that, however much scientists may differ as to the amount of the loss of the supporting power involved, none will dispute that there will be a very great loss.

Yet again, if these descents from favouring suppositions to sober facts will not convince, I must advance one more argument. It is, I believe, like the others, new ground, and I will give it a fresh paragraph.

Flying-fish, at the end of their first flight of usually about 10 to 50 yards, have a habit, especially when approaching the crest of a wave, of momentarily checking their wing-movement and slowing down from the blurr of great rapidity into a pace in which the flapping of the wing becomes easily visible. This period of visibility is supposed by aeroplanists to be the only portion of the flight during which the wings move, and they even deny them at this time any supporting power whatever. It is their "period of occasional vibration" or "fluttering," and their explanation thereof will make a mechanician smile or feel sad, according to his temperament. I have already quoted it from Möbius, and it amounts to the wings trailing in the wind like a loosely flapping flag, thus not only depriving the heavy fish of the so-called support of its miniature aeroplanes, but actually converting them into an active drag.

And yet, according to the theorists, at an extreme suggested speed of $13\frac{1}{2}$ miles an hour, the fish still sails!

Such an upsetting of one of the best known of nature's laws as all the foregoing implies would be impossible of final acceptance, even if we could not, as many of us can, see the flying-fish flying.

I studied the "vibration" or flutter periods very carefully this spring when returning from the Gulf of Mexico. Their object and method seemed simple and clear, and to be as follows:—The slowing down from extreme wing-speed into visibility heralds an immediate increased effort of flight, often, if not usually, to enable the fish to surmount a wave. The fish is, in fact, pulling itself together for a spurt. The flutter, as was to be expected, is accompanied by a slight fall of the fish of perhaps 2 or 3 inches; but the spurt, at once put on, regains the lost elevation and lifts the fish well over the obstacle. This sudden rise of the fish (the "frequently overtop each wave" of Möbius) is constantly to be seen, and to many the wings seem still at this time.

The difference in the rates of speed of wing-flapping noticeable on different days is very marked. At times, and often for many successive days, it is noticeable that, although the bodies of the fish as they rise from under the steamer's bows are clearly and sharply defined, their supporting wings have a peculiar hazy and blurred look, with a want of definition of outline which cannot be accounted for, for they seem to be still. Then a day will come when the fish, still fleeing in front of the ship, will move their wings less rapidly and their motion will become plainly visible. There are still many lookers-on who cannot pick it up, but for the rest the aeroplane theory is exploded for ever, and when next the swifter-moving wings are seen with the eye of knowledge the wonder is that there had been any difficulty. The haze and blurr are exactly what should have been looked for under the circumstances.

We have all of us watched sea-gulls soaring quietly in a certain direction, but obliged to flap when they turn away, the vigour of the flapping varying more or less regularly with the direction in which they meet the wind. It is more than probable that the change of wing-speed of the fish varies for similar reasons in degree of rapidity, soaring being, as I have endeavoured to show, quite out of the question. From whatever cause, it certainly does so vary.

A curious thing about the "vibration" periods is that they seem to offer fleeting glimpses of a satisfactory wing; for a moment, now and again, the wings have outlines and edges, and will also occasionally return a sun-glare to the eye from their wet glassy surfaces, such as might be expected from them when not whirring. Such a glare is also now and then momentarily to be seen when a fish ceases flying, and just before it strikes the water, if it be in the proper position with regard to the sun. There would, of course, be many long periods of this glare were the wings really still.

One or two more prominent fallacies are handed on from writer to writer, and often accepted as facts. One is that the fish are helped in their flight by the distention of their air-bladder. If such had any appreciable effect it would be that of impeding the flight, for the contained air being under compression would be denser and therefore heavier than the outside air, and the increased size of the fish would merely check its speed as a hollow bullet is checked.

Steering-power is also denied to the fish by most naturalists. It is, nevertheless, a matter of common seafaring knowledge that they turn with deliberate intention. I have myself watched one fly towards the ship, and, circling back, finish its flight in a direction straight away from the ship. It approached within a yard or so of the side, close under where I was standing. The check of speed on its first taking alarm was marked, and during the turn of half a circle of about 10 or 12 feet radius which it made it could not have been flying at a rate of more than three or four miles an hour.

Again, they rise quite at will, though this power also is denied by aeroplanists. With reference to this, as well as to their power of steering, the late Earl of Pembroke, or Doctor G. H. Kingsley, joint authors of 'South-Sea Bubbles,' says (p. 64, 7th ed., 1895) :—"Flying-fish *do* fly, moving their pectoral fins with extreme rapidity, moreover, they raise and lower themselves over the tops of the waves, and do *not* dip into them, ... I remember between Panama and Rapa I used to see the cabin's bulls' eyes surrounded by a circle of scales every morning left there by flying-fish." They were making for the light. No ingenuity can fasten this upon "currents of air," which are credited with so many other impossible feats on behalf of these fish. This habit of theirs is quite well known, and is effected by raising themselves and steering, pure and simple.

Their taking a baited hook is also denied. As a matter of fact, a baited hook is the first part of the fishing-process of the Barbados flying-fishing fleet, with which I have been out. We had a blank day; but, according to the animated description of the boatmen, the struggles of the first victim bring round it swarms of sympathisers (as gulls flock round a wounded companion), and these are "raked" into the boat by the hand hoop-net, an enlarged edition of a round shallow shrimp-net without any handle.

I have throughout this paper spoken of flying-fish generally, for the wing-areas of all of the known kinds are to their weights and speeds such that the impossibility of their practical use as aeroplanes differs only in degree.

Flying-fish put on different aspects according to the state of air and sea. One is rather startled at times by the changes in their methods. In oily equatorial calms, I have watched them in numbers flying long distances with their tails in the water and their heads and wings in the air, the body making an angle of perhaps 30° or 40° with the horizon. The wake left in the water by the dragging tail showed, as well as I could judge, no signs of its having been used for purposes of propulsion, even in its own element, and it is, perhaps, simply to relieve the fish of its weight that it is so supported when there is no fear of the wings being caught by ruffled water; nevertheless the peculiar long lower half of these tails specially adapts them for use as auxiliary propellers to a fish which, with their exception, is a "fish out of water"; and it looks so like a case of natural evolution, that I feel inclined to doubt the justice of my personal observation as to their non-use.

It would seem, from this habit, reasonable to suppose that the fish have the power of flapping their wings at various angles, as have birds, as ordinarily their bodies are fairly horizontal as they fly.

The flight of these fish is often described as "graceful," "light," and so on. To him who believes that they soar along easily for 200 yards without further effort than a preliminary leap from the sea, such an opinion may be a natural one.

To him who recognizes that such a leap is mechanically impossible, whether or not assisted by a continuous tail-movement, or to him, who, without thinking particularly about it, simply sees the heavy labouring of the wings as the fish patiently whirrs along its even, uneventful way, "graceful" and "light" are terms misplaced. Strenuous, persistent, plodding effort is the impression left upon the mind, the least failure in which effort means plumping into the water. One often sees this happen obviously without intention on the fish's part.

In conclusion, it is, I think, made clear :—

1. That flying-fish would require to have a wing-area several (and probably many) times greater, according to their weights, than they actually possess to enable them to accomplish sailing flight in even such a restricted form as that carried out by sailing birds.
2. That we know of no parallel case in nature which would justify the assumption that the possession by these fishes of even such increased wing-area would of necessity enable them to sail long distances—(*a*) horizontally, or (*b*) close to an obstruction (the sea), or (*c*) in defiance of the direction of the wind; much less all three (*a*), (*b*), and (*c*) combined, as they commonly fly.
3. That their common flight is exactly what is to be expected of flyers holding, as they do, a very low wing to weight ratio—flyers capable of, and of necessity employing, extreme wing-speed.

XXII.—*A new* Heterotanais *and a new* Eurydice, *Genera of Isopoda*. By Canon A. M. Norman, M.A., D.C.L., LL.D., F.R.S., &c.

[Plates V. & VI.]

Genus Heterotanais, G. O. Sars.

The genus *Heterotanais* was established by Sars in 1880 ("Revision af Gruppen: Isopoda Chelifera," Arch. f. Math. og Naturv. p. 28), and four species were assigned to it :—*Heterotanais Örstedi* (Kröyer), Scandinavian; *H. anomalus*, sp. n., Mediterranean; *H. limicola* (Harger), N.E. American; and *H. tenuis* (Thomson), New Zealand. More recently M. A. Dollfus ("Campagnes de la 'Melita,' Tanaidæ &c.," Mém. Soc. Zool. de France, vol. xi. 1898, pp. 37-47) has assigned